

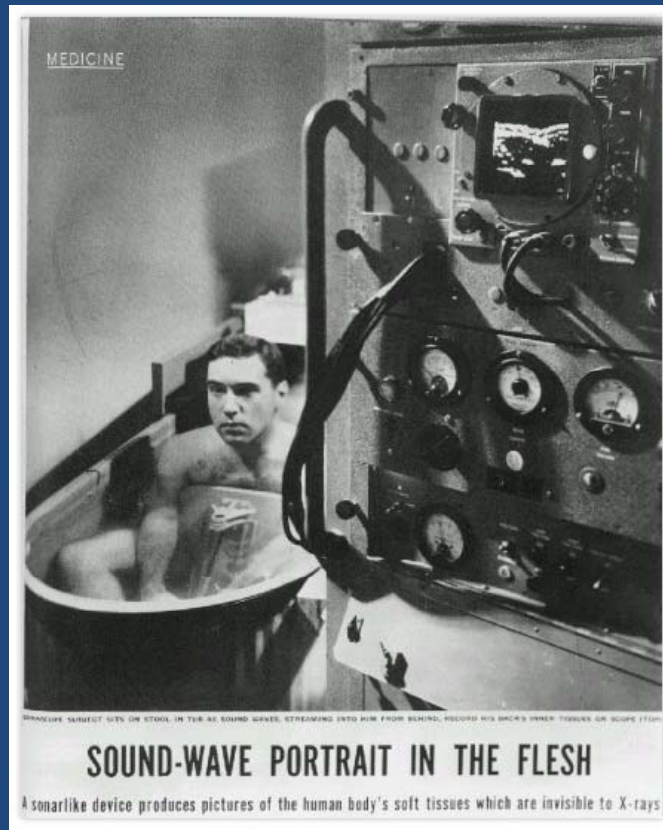
Critical Care Ultrasonography

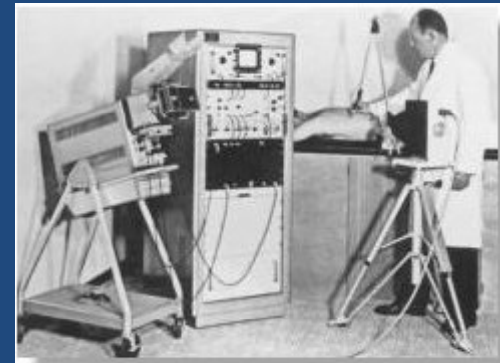
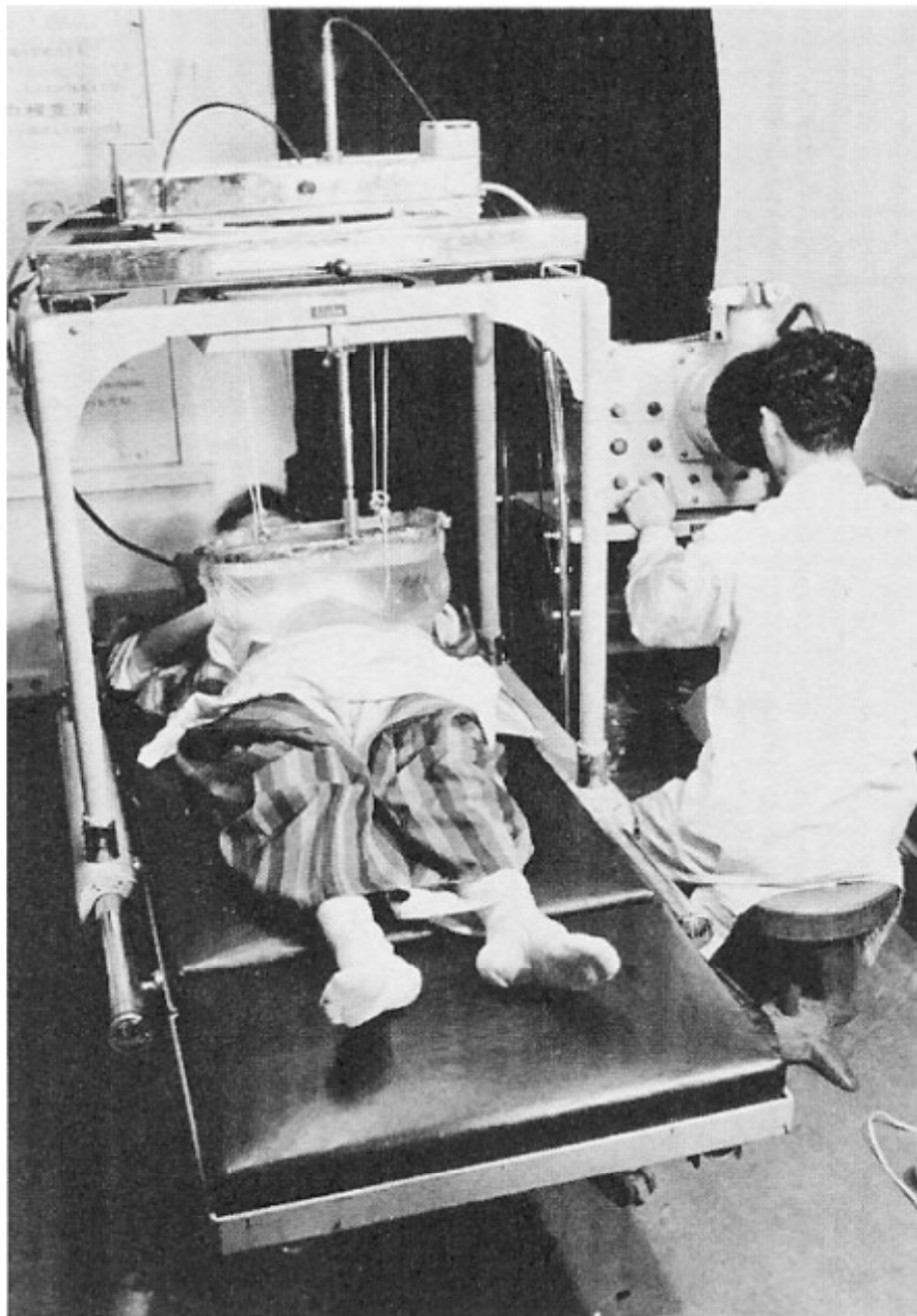
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I Have No Disclosures

From Then to Now

- 1883: description of piezoelectrical effect
- 1912: Titanic Disaster
- One month later, first device to utilize sonography to locate icebergs
- Rapid development of technology for military applications
- Practical SONAR devices used in WW1 (Sound Navigation and Ranging) and its relative RADAR (Radio Detection and Ranging)
- Further work with major application of SONAR in WW2
- 1940's: development of ultrasonography for assessment of metallurgy (armored plate/piping integrity)
- Logical extension imaging applications
- Late 40's and early 50's: considerable activity in therapeutic ultrasonography....initial enthusiasm....limited validated applications





The articulated arm scanner that Wright and Meyerdirk built in 1962, the earliest of such design in the U.S.

1970's

- M mode crystal attached to Sunbeam® electronic toothbrush
- Results in 1st successful 2D device
- 1973: 2D probe with Doppler capability
- Rapid evolution of probe design: mechanical to electronic control of beam

1980-1990

- Widespread availability of well designed machines
- Well trained ultrasonography technicians
- Standardization of scanning techniques
- Standard part of radiology/cardiology training
- Extensive descriptive research
- By 1990, a mature imaging modality, fully validated, widespread use radiology/cardiology

1990 Onwards: Some Interesting Facts

- In Germany, internal medicine graduates required to complete 400+abdominal scans
- In Europe, ultrasonography technicians not used: the clinician does the scan
- In the EU, clinicians are required to use the modality that delivers the lowest radiation exposure....CT is not permitted if US rules
- IM trainees in Japan: thousands of abdominal scans
- In USA, EM starts to introduce ultrasonography

What About Critical Care US?

- We are about 10 years behind EM
- It starts with Dr. Daniel Lichtenstein in 1990
- First WBU article in 1993
- Slow dispersion of his approach via textbook(s) and seminal articles on lung US
- The Italians jump in, the French follow with focus on echo
- Several European Consensus Statements

2000 onwards

- Refinement of standard 2D and Doppler imaging technology
- Development of speckle tracking, stress, strain, 3D imaging, intracardiac echo
- The gradual demise of M mode
- The rise of critical care echocardiography
- In parallel with improvement of small machine design

Big versus Small

- Critical care echocardiography generally performed with portable machines
- Advantages: size, portability, durability, ease of operation, reasonable image quality, good Doppler quality, cost
- Disadvantages: lower image quality, no advanced capability (strain, 3D etc.), no sophisticated image controls

The Coming Revolution

- Low cost ultra-portable machines
- High quality 2D images but limited Doppler
- Not yet for ACCE, but the day will come
- Microprocessor array element permits single cardiac/abdominal/vascular probe for 2K
- Ultra-portables will eventually be fully Doppler capable

How to Deploy Critical Care Ultrasonography

**Full Integration on Rounds
Day and Night Use in ICU
RRT/Codes/Consultation**

**Consider Having Some Team
Members with Advanced Critical
Care Echocardiography Training**



Monday

16/18 Beds AM rounds

- Limited Chest: 12
- Limited Echo: 12
- Limited Retroperitoneal: 4
- Limited Abdominal: 4
- DVT: 3
- Misc: 4
- PM: 4 admissions with full WBU
- 5 US guided procedures
- TEE: 1
- CXR: 2, formal cardiology echo 1, DVT 1

CCUS In USA....

- The ACCP/SRLF Statement....still widely used
- CHEST training courses
- Local cooperative courses for fellows
- ACGME on board
- Fellows coming out trained; field spreading from down to up
- What barriers remain?

Barriers in USA

- 1. Lack of buy-in from senior leadership
- 2. No longer a lack of machines
- 3. Lack of faculty at fellowship level
- 4. Lack of definitive training for attending level intensivists
- 5. Local credentialing issues
- 6. Concern that, in come cases, training will be inadequate leading to poor clinical outcome

Critical Care Ultrasonography

- What?* Any component of ultrasonography that is relevant to (EM/ICU) function
- Where? ED/ICU/RRT/Anywhere
- Who? ED/intensivists/NP/PA
- When? Immediately/repeatedly/in goal directed fashion/routinely

Mayo PH, Vieillard-Baron A. et al. American College of Chest Physicians/La Société de Réanimation de Langue Française Statement on Competence in Critical Care Ultrasonography. Chest 2009 135:1050-1060

Why?

- Fully validated imaging technique
- Machine design allows point of care use
- Intensivists able to achieve high level skill
- Standard use on consultative basis
- Common sense application for diagnosis and management of critical illness

Why?

- To avoid the problems associated with radiology/cardiology performed US:

Time delay in performance

Time delay in interpretation

Time delay in communication

Clinical disassociation

One time examination

No limited examination

Basic Principles

- The examination is performed by the clinician at the bedside of the patient
- The examination is interpreted by the clinician at the bedside of the patient
- The results are immediately applied at the bedside of the patient
- The examination may be limited in scope and repeated as needed

The Roadmap

CHEST

Official publication of the American College of Chest Physicians



American College of Chest Physicians/La Societe de Reanimation de Langue Francaise Statement on Competence in Critical Care Ultrasonography

Paul Mayo, Yannick Beaulieu, Peter Doelken, David Feller-Kopman, Christopher Harrod, Adolfo Kaplan, John Oropello, Antoine Vieillard-Baron, Olivier Axler, Daniel Lichtenstein, Eric Maury, Michel Slama and Philippe Vignon

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Additional Resources

- Cholley, B. International expert statement on training standards for critical care ultrasonography Expert Round Table on Ultrasound in ICU Intensive Care Med 2011;37:1077-1083
- Mayo PH, Vieillard-Baron A, International consensus statement on training standards for advanced critical care echocardiography. Expert Round Table on Echocardiography in ICU. Intensive Care Med. 2014;40:654-66
- Frankel HL et al. Guidelines for the appropriate use of bedside general and cardiac ultrasonography in the evaluation of critically ill patients—part I: general ultrasonography. Crit Care Med. 2015 Nov 1;43(11):2479-502.
- Levitov A et al. Guidelines for the appropriate use of bedside general and cardiac ultrasonography in the evaluation of critically ill patients—part II: cardiac ultrasonography. Crit Care Med. 2016 Jun 1;44(6):1206-27.

Whole Body Ultrasonography (WBU)

- Combines multiple aspects of CCUS into a single examination sequence
- Typical sequence for patient with shock: basic CCE exam (5 views), bilateral lung, DVT study
- Abdominal (limited) as indicated
- Strong clinical logic to using WBU for routine evaluation of cardiopulmonary failure
- Not a new concept:

Lichtenstein D, Axler O (1993) Intensive use of general ultrasound in the intensive care unit. Prospective study of 150 consecutive patients.
Intensive Care Med 19:353–355

Does WBU Work?

- A must read article
- Volpicelli G. Point-of-care multi-organ ultrasonography for the evaluation of undifferentiated hypotension in the emergency department. Intensive Care Med 2013;39:1290–1298
- 108 patients with “undifferentiated hypotension”
- 100% correlation between dx by WBU and final committee consensus dx....**100%!!!!**
- 4.9 minutes per examination (basic cardiac, thoracic, DVT, limited abdominal)
- Multiple other studies reporting unexpected and clinically relevant findings with impact on therapy

e.g. Laursen C Focused Sonography of the Heart, Lungs, and Deep Veins Identifies Missed Life-Threatening Conditions in Admitted Patients With Acute Respiratory Symptoms Chest 2013;144:1868-1875

How About Respiratory Failure?

Strong Utility

- Silva S et al. Usefulness of cardiothoracic chest ultrasound in the management of acute respiratory failure in critical care practice. Chest. 2013;144:859-65.
- Bataille B et al. Integrated use of bedside lung ultrasound and echocardiography in acute respiratory failure: a prospective observational study in ICU. Chest. 2014;146:1586-93

Consider This

- As a stand alone examination, WBU establishes early diagnosis and guides therapy
- WBU is never performed *in vacuo*
- Results of WBU are integrated with history, physical, initial imaging, and laboratory values
- A powerful synergy of imaging modality with clinical reality

What is the Alternative?

- Chest radiography? Zanobetti M et al. Can Chest Ultrasonography Replace Standard Chest Radiography for Evaluation of Acute Dyspnea in the ED? *Chest* 2011;139:1140–1147
- Xirouchaki N et al. Lung ultrasound in critically ill patients: comparison with bedside chest radiography. *Intensive Care Med.* 2011;37:1488-93
- Chest CT? Lichtenstein D et al. Comparative diagnostic performances of auscultation, chest radiography, and lung ultrasonography in acute respiratory distress syndrome. *Anesthesiology.* 2004;100:9–15.
- Call cardiology for echocardiography?
- Call radiology for DVT study/abdominal US?
- There is no alternative for immediate evaluation of CP failure

The Same Tired Argument

- There is no evidence that WBU improves patient outcome
- Answer #1: The same holds for all other imaging modalities in use in the ED/ICU
- Answer #2: Some truths are so self evident, that we must hold them to be true.
- Answer #3: Accurate diagnosis is a cornerstone of modern medical practice
- Answer #4: Are you competent in critical care ultrasonography?

What To Do?

- What to know
- How to train
- How to determine competence
- How to maintain competence

Fellows: The Golden Years

- Highly motivated learners
- No blocks to acquiring new skill
- Plenty of time to train
- ACCE is an option
- Local cooperative courses
- The main challenge:
- Faculty capability

Attendings: A Challenge

- Limited time for training
- Competition with other responsibilities
- Economic barriers
- Unfriendly training environment
- Credentialing challenge
- Solution: OJT solution....it works
 - CHEST COC program
 - In large group, reliance of partners
 - (relevant to ACCE)

For the Adventurousome

- National Board of Echocardiography Certification in advanced critical care echocardiography (ACCE)
- Cooperative project with CHEST, ATS, SCCM, ACEP, ASA, ASCA, ASE and NBME
- 1st board exam 1/15/19....600 candidates
- Challenging image acquisition requirement

Interested in ACCE?

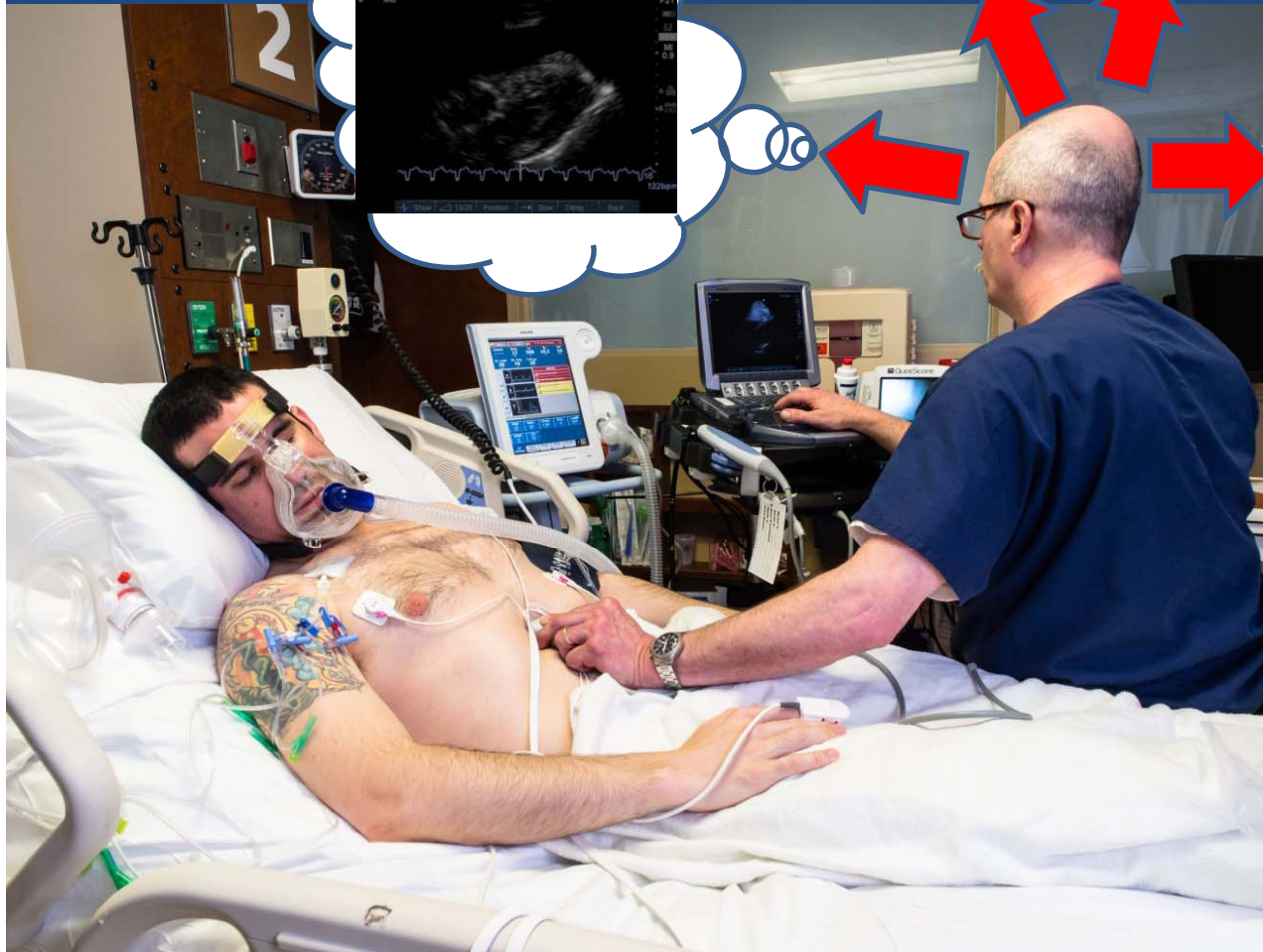
- Fellows: time to train, no conceptual barriers, patient care orientated, desire to excel, professional development
- Attendings: verification of capability, practice related requirements, a challenge to be met, desire to learn, professional development
- My prediction: 600 this year....800 next year
- ACCE intensivist may largely replace consultative echocardiography in ICU
- But never completely! (artificial valves, decision on valve surgery, complex congenital, strain, ICE etc.)

The New Paradigm



A new paradigm

You do the history
and physical and....



You do the ultrasonography

Immediately
Repeatedly
Routinely

22 Female with 1 week prodrome of
fever/malaise

Acute Dyspnea/Severe Hypotension
Intubated in ED

On pressors with refractory hypoxemia
1st Year Fellow Scan

Bilateral B Lines (whiteout) with Smooth Pleural Surface



LLL PNA with Mobile Air Bronchograms

Small Anechoic PLEFF



What to Do?

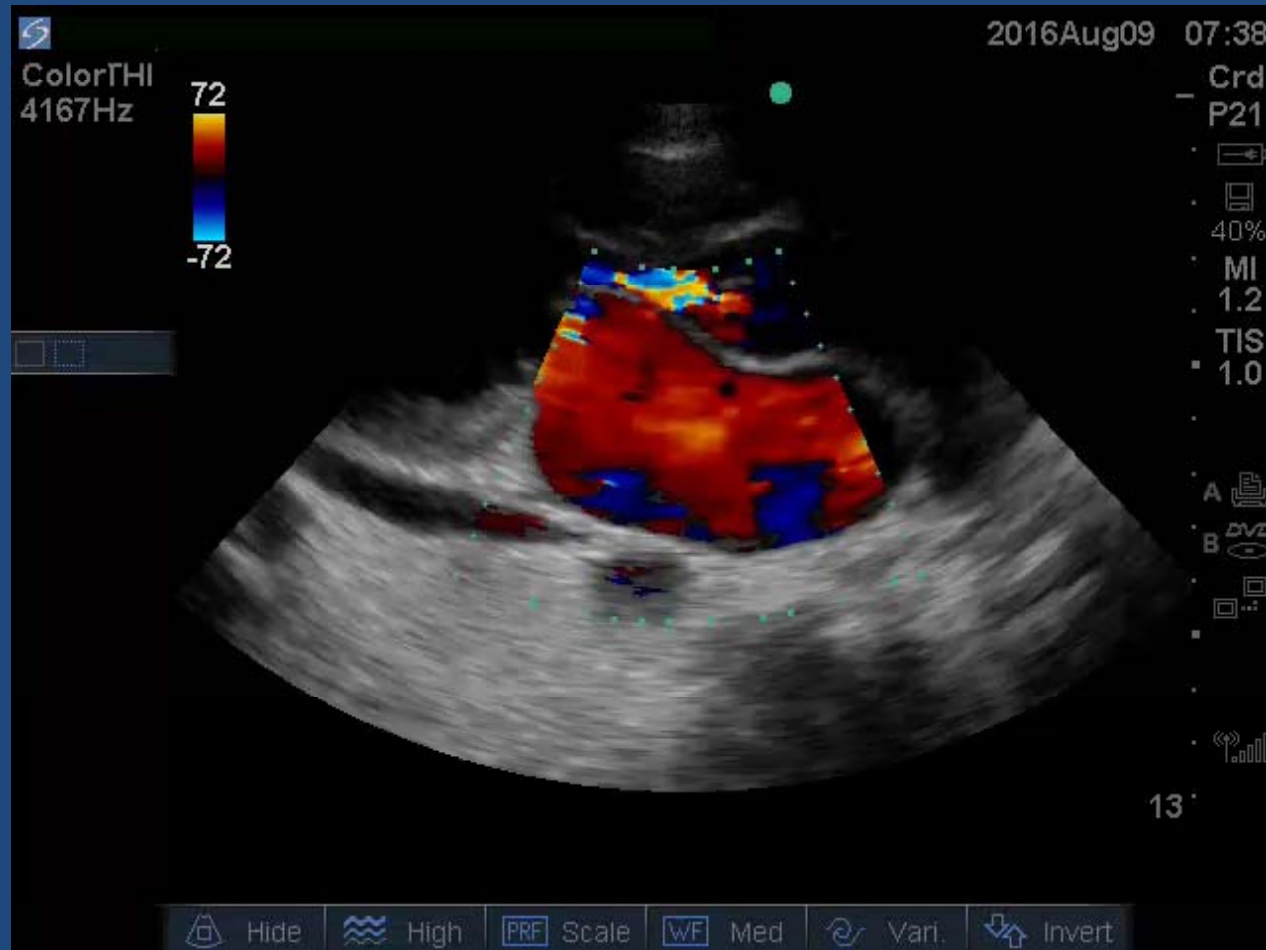
MS with Vegetation



Zoom



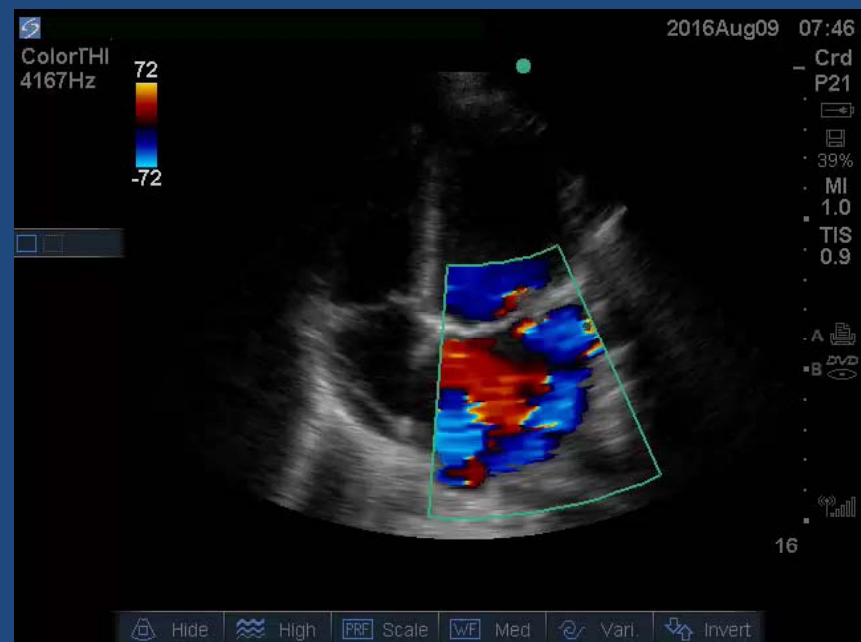
Severe MR



PSL



AP4



SCL and IVC

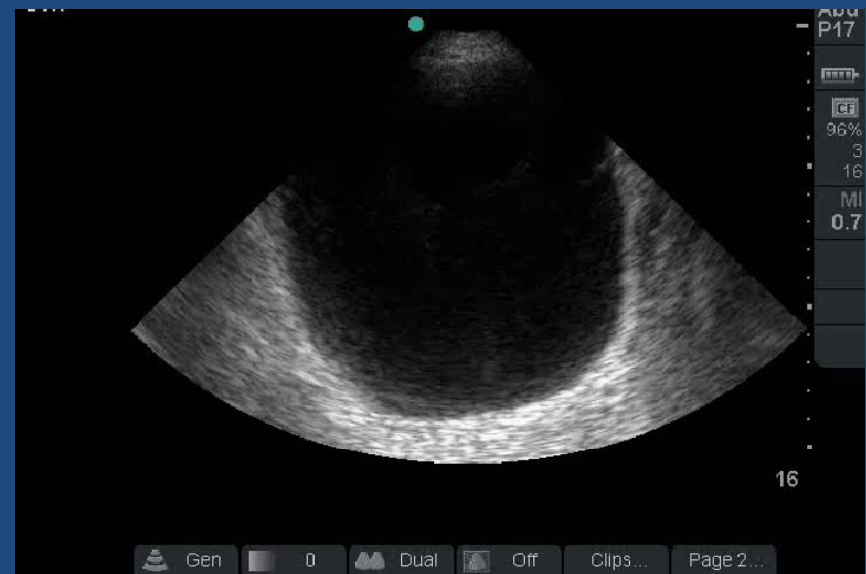


Anuric

No Hydronephrosis R&L



Foley for Resolution



DVT Study Negative

